A revisit of the Basic Angle Stability

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The error budget document for the Full–Sky Astrometric Mapping Mission (FAME) is laid out in document NCST–D–FM003. The most recent version that I am aware of is dated 29 October 2001. I believe this document may currently be undergoing revision.

The basic angle stability is currently listed in section 4.4.4.1 as being 0.05 nanoradians over 10 minutes, with a caveat of To Be Resolved next to it. I would like to make the argument at this time that we are being over conservative with this number. The result of the specification of the basic angle leads to constraints on the temperature gradients allowed near the compound mirror, the materials used to construct the compound and primary mirrors, and the support structures. Lockheed memos EM008 and EM037 show that as of January 2002, LMC had not met the spec. Obviously specifying too stringent a limit on the basic angle stability will cost money that might be better allocated to a different part of the error budget.

I would like to present two different arguments that suggest that the basic angle stability of 0.05 nanoradians per 10 minutes may be as much of a factor of 10 over conservative.

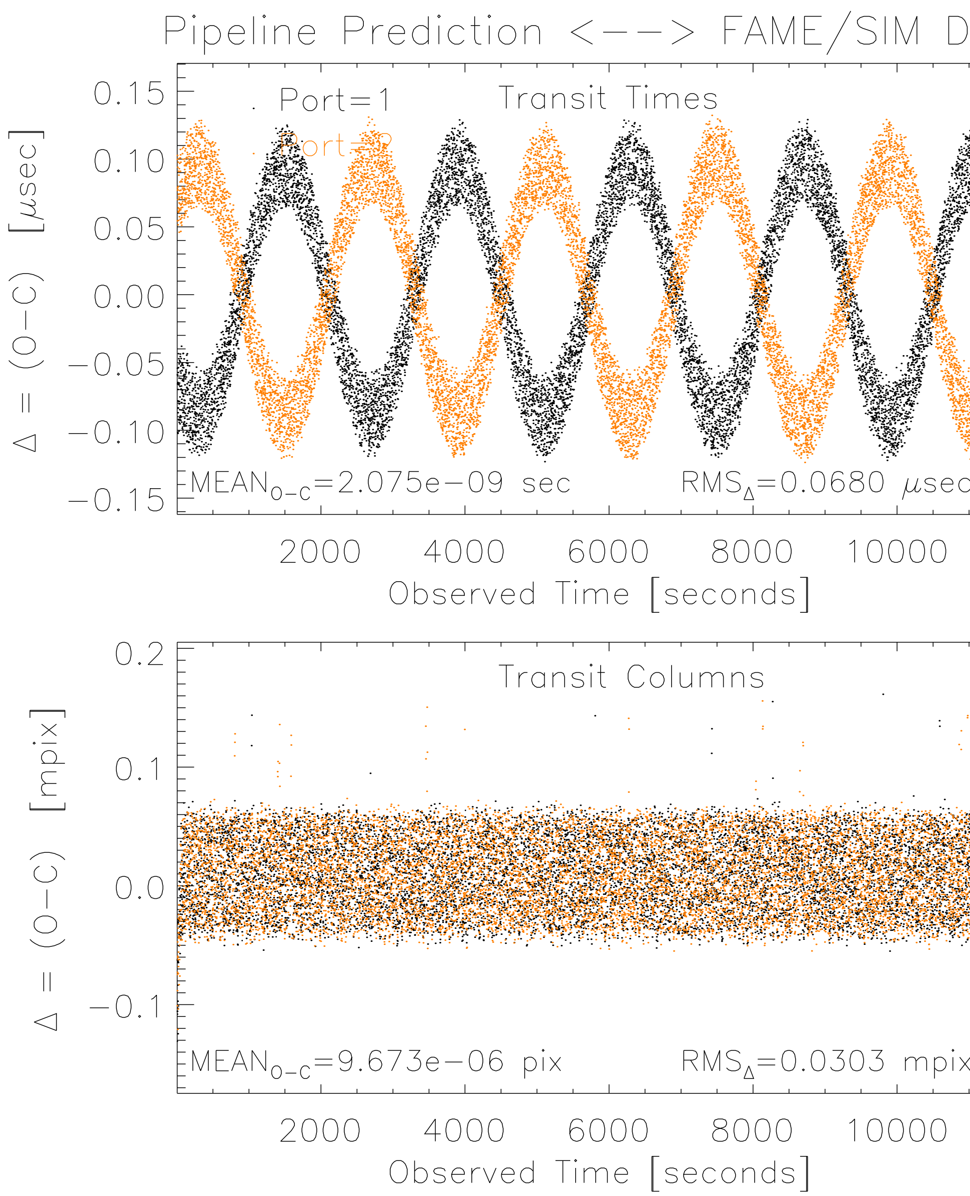
- If we consider a 10.5 meter focal length, and a pixel size of 15 microns, a 0.05 nanoradian change in basic angle corresponds to a 35 micro–pixel change. The basic centroiding of 1/350th of a pixel corresponds to approximately 2,800 micro–pixels. This implies that the change in the basic angle is a negligible part of the centroid error, which may in fact have been where the specification came from, but if we can save money by having the change in basic angle be one 10th the centroiding accuracy rather than one 80th, we should explore this carefully. I have not been able to find a full error budget for the one dimensional centroiding, but having an entry for 350 micro–pixels added in quadrature to a existing 2800 micro–pixel uncertainty raises the uncertainty to 2820 micro–pixels.

- I have run the simulator and pipeline over 25 days of simulated data, using 8 three hour spirals per day, for a total of 200 spirals. The CPU time on the computer Leo for this is about 2 days to run the simulator, and then 1.5 days to run the pipeline on it. I calculated two sets of data, one with a constant basic angle of the nominal mission accuracy, one one data set with a basic angle that varied by a sinusoid of amplitude 100 microarcsec and a period of 40 minutes. This yields a worst case change in basic angle of 157 microarcsec per 10 minutes. After I create O–C's for all the guide stars in the simulations, I calculated new positions for all guide stars with at least two "visits". Stars with only one visit would be relatively unconstrained and have highly correlated errors between the RA and DEC solutions. The solution for the varying basic angle showed a RMS error of 4 microarcsec, which seems the right order of magnitude to be included the desired accuracy of 50 microarcsec.

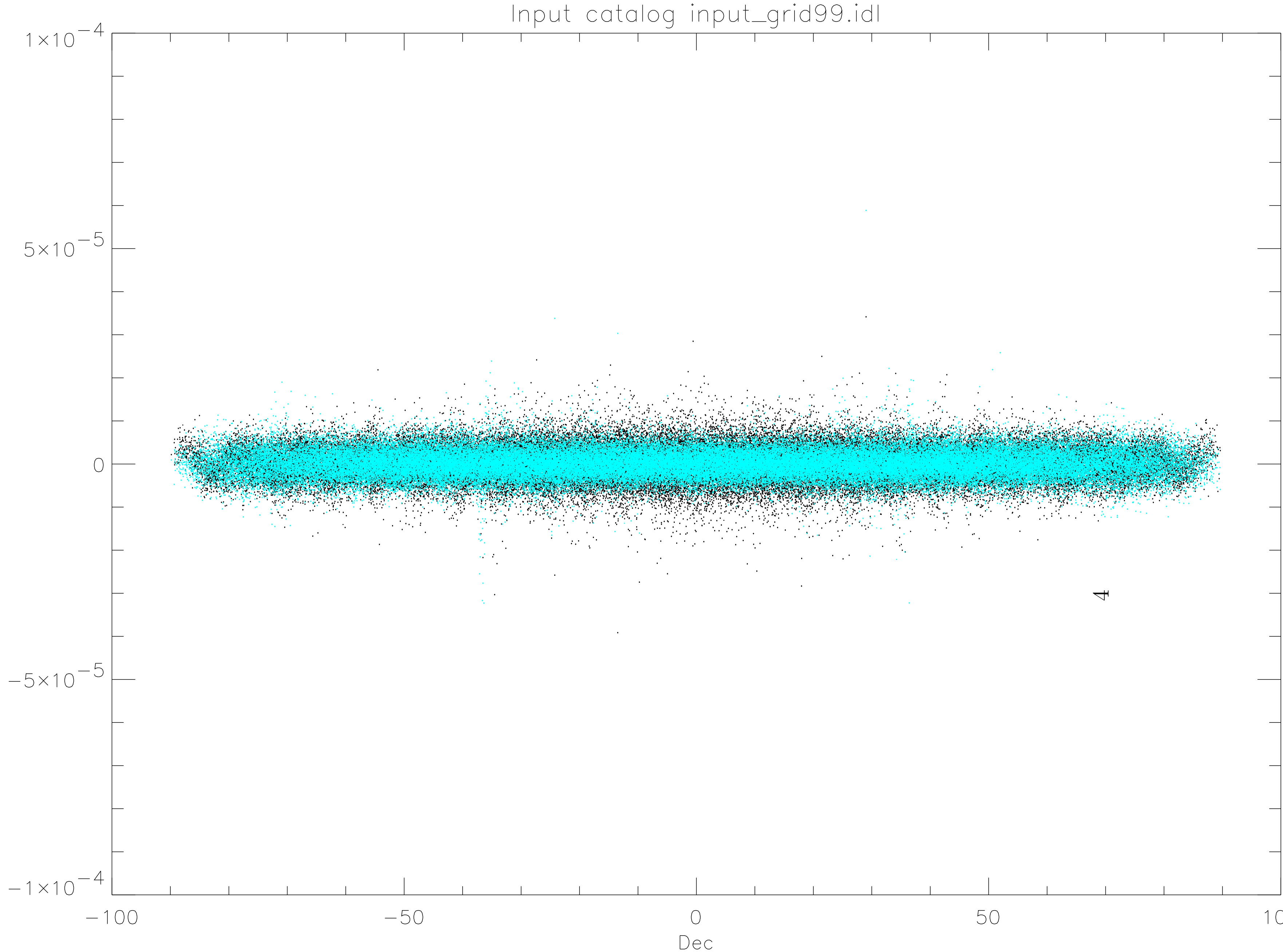
Figure one is the O–C residuals from one of the 200 spirals ran with a 100 microarcsec over 40 minute variation in the basic angle. The "noise" visible is from the truncation in the data model of the x and y centroids at the 1/10,000th of a pixel. As a reminder, the centroiding accuracy of 1/350th of a pixel is a factor of 28 times larger than the oscillation shown.

Figure two is the offsets in position from the 77,867 grid stars that had at least two "visits" during the simulation. The abscissa is in arcseconds, the black dots are the declination changes,and blue dots are the right ascension. I have corrected for the cos(DEC) factor.

I have not considered changes in the basic angle on "short" timescales, short being defined as approximately the rotation period. Our ability to recover basic angle changes will be greater for longer time periods than it will be



for short periods.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5×10^−5
0
−5×10^−5
−1×10^−4
−100
−50
0
50
10
Dec